

24.

Reproductive Activities of a Hybrid Minnow, *Notropis cornutus* × *Notropis rubellus*.

EDWARD C. RANEY

Department of Zoology, Cornell University, Ithaca, New York.

A considerable number of natural hybrids have been recognized in recent years among American Cyprinidae. One of the most common is the cross between the common shiner and the rosy-faced shiner, *Notropis cornutus* (Mitchill) × *Notropis rubellus* (Agassiz). The subspecies of *Notropis cornutus* involved appears to be unimportant and hybrids of *Notropis rubellus* with subspecies *cornutus*, *frontalis* and *chrysocephalus* have been found occasionally throughout their range. Hubbs & Brown (1929, p. 37) have pointed out that hybrids of this combination were misidentified as *Notropis pilsbryi* by Forbes & Richardson (1909, p. 149).

It has generally been assumed that the hybridization in this as well as in other minnow combinations is due to chance fertilization. The breeding habits of *Notropis cornutus* and *Notropis rubellus* in some localities are such that they are thrown into close contact at the spawning time. Both species may utilize an unprepared gravel bottom in running water for breeding but appear to prefer the pebble nests of the river chub, *Nocomis micropogon*, and the horny-headed chub, *Nocomis biguttatus*, when these are available. However, *Notropis cornutus* is quite adaptable and has been observed (Raney, 1940, p. 6) digging a shallow nest in riffles. In the reported observations of *cornutus* and *rubellus* spawning in close proximity, it has been over a *Nocomis* nest. Hubbs & Brown (1929, p. 37) "observed *rubellus* mating in midwater a few inches over the heads of breeding *cornutus*." They also noted that this hybrid combination was most common below obstructions where a large number of *cornutus* and a considerably smaller population of *rubellus* were present. This is in agreement with my observations in Catatonk Creek at Candor, New York, (Susquehanna Drainage), where many hybrids have been collected and numerous others seen in an area of gravel riffles below an impassable dam. At this locality practically all of the spawning of *rubellus* and much of that of *cornutus* takes place over the nests of *Nocomis micropogon*. The use of *Nocomis* nests by *Notropis cornutus* or *Notropis rubellus* has been reported by Greeley (1929, p. 172, and 1938, p. 67), Hankinson (1932, p. 417), Hubbs & Brown (1929, p. 37), Hubbs & Cooper (1936, p. 49), Raney & Lachner (1939, p. 160) and Raney (1940, p. 7). Hankinson (1932, p. 417) describes the breeding behavior of *rubellus* as follows: "Spawning could be seen among these rosy-faced minnows since it always took place high above the other fish of the aggregation (mostly *cornutus*) and several inches above the gravel. The males would collide with the females, striking them on or near the head with their roughened snouts, and the two would contort themselves in a way that suggested spawning."

Several times in the past few years, during late May and early June, both *cornutus* and *rubellus* and hybrids between them have been observed

over *Nocomis* nests. The hybrids of both sexes appeared to be in a condition of sexual ripeness. The nuptial tubercles were well developed in the males, and they showed the red colors that are apparent in the breeding season. The females contained well developed eggs and some of them showed red nuptial colors and tubercles. A suspicion that these hybrids were capable of spawning was confirmed during the past spring (1939) when a number were seen performing the breeding act.

RECOGNITION IN THE FIELD.

The recognition of these hybrids in the field became relatively easy after one had watched them for many hours. The hybrids were intermediate in body shape between the parent species, *cornutus* and *rubellus*, and could be distinguished by this character alone. The spawning hybrids were slightly larger than any male *rubellus* seen at this locality. However, the breeding color of the males furnished the best clue to their identification. The following color characters (not apparent in preserved specimens) were noted in breeding males when viewed under water under natural conditions.

<i>Notropis c. cornutus</i>	Hybrid	<i>Notropis rubellus</i>
The mid-dorsal stripe and the stripe on each side of the back were conspicuous and varied from a bright silver to a light green against the dark background of the back. These stripes were outstanding highlights and could be seen at a considerable distance. The snout was dusky.	The stripes were easily seen but were red. The snout was slightly red.	The stripes were absent or indistinct and the anterior half of the body was bright red. The snout was slightly red.

The following brief color descriptions of males were taken after several hours' preservation in 10 per cent. formalin. In *Notropis c. cornutus* the sides, the branchiostegal region and at times the lower part of the cheek and opercle, the paired fins, and the outer or posterior border of the median fins were red. The upper parts of the cheek and opercle were a slate blue as was a narrow band immediately behind the opercle. The back was nearly black, with the mid-dorsal and lateral light stripes mentioned above.

In the hybrid, *Notropis c. cornutus* × *Notropis rubellus*, the sides, branchiostegal region, the lower cheek and opercle, the back at the base of the dorsal fin, the pectoral and to a lesser extent the pelvic and anal fins were red.

In *Notropis rubellus* the snout, chin, top of head, anterior half of body, the base of the dorsal fin, the base of the pectoral fins and to a lesser degree the base of the ventral fins were red.

The degree of development of breeding tubercles in the male hybrids is interesting as they appear to have both the pattern and size of the tubercles possessed by both the parent species. In ripe males of *rubellus* many small tubercles cover the chin, snout, top and side of head, upper two-thirds of the opercle, and the posterior edge of almost every scale on the back and upper sides. All fins are covered with small tubercles. They are best developed on the upper sides of the pectoral fin and least developed on the anal fin. In males of *cornutus* there are fewer but larger and sharper tubercles on the chin, snout, top of the head, and on the back in front of the dorsal fin. A few minute tubercles are found on the upper sides. In male hybrids there are many fine tubercles at approximately the same positions on the body and fins as in the parent species. There are also several dozen larger tubercles on the top of the head, as in *cornutus*.

SPAWNING OF HYBRIDS.

Observations of spawning hybrids were made on June 10, 1939, in Catatank Creek, two miles south of Candor, New York. On this date *Notropis c. cornutus* had about reached the end of its breeding season and no spawning males of this species were seen (the spawning season had reached its peak about June 1, when practically every *Nocomis* nest was occupied by 5 to 25 *cornutus* males). Many ripe adults of *Notropis rubellus* were seen over the same *Nocomis* nests, but were also seen as late as June 10 spawning over gravel shallows in riffles.

At 5 P.M. on June 10, when the water temperature was 69° F., the air 66° F., a group of hybrids, *Notropis c. cornutus* × *Notropis rubellus*, was seen over a nest of *Nocomis micropogon* (the only species of *Nocomis* found in Catatank Creek). The nest, roughly two feet in diameter, consisted of stones up to two inches in diameter piled to a height of four inches above the general level of the gravelly creek bottom. It was located in moderately swift water at a depth of 10 inches. The stream at this point was 70 feet wide and the nest was about 25 feet from shore. Many *Nocomis* nests were available in this area of Catatank Creek but few were located in as fast a riffle as this particular one and relatively few were occupied by spawning fish at this late date.

At various times, from 10 to 16 male hybrids ranging in standard length from 65 to 75 mm. (as determined by measuring captured specimens) were seen facing upstream over the *Nocomis* nest. They attempted to maintain a definite position and generally an individual did not move more than five inches in any direction. They alternately moved to right and left a few inches and, in general, their behavior was similar to that of spawning *rubellus*, males of which hold positions facing upstream, shifting to either side and striking an adjacent male from time to time but not moving far from the original position. The *rubellus* and hybrid males differed in behavior from those of *cornutus* mainly in that they did much less fighting for position and did not drive away predators slightly larger than themselves.

Many *cornutus* females were observed below the nest, occasionally coming up over the males and, at times, continuing upstream in front of the nest. A number of individuals of both sexes of *rubellus* were seen both over the downstream half of the *Nocomis* nest and over the gravel below the nest but they were not observed spawning although the males jockeyed some for position. The *rubellus* males and females occupied a slightly higher stratum than the *cornutus* females and the hybrids, which were down over the pebbles of the nest so that the lower fins at times appeared to be in contact with the bottom.

The spawning act was identical with that observed for *cornutus* as recently reported in detail (Raney, 1940). A female *cornutus* came upstream over a hybrid male and dipped down to lie along side him. He threw his caudal peduncle over hers and lifted his pectoral fin which was inserted underneath the front end of her body. This activity forced her firmly against the bottom of the nest, where she rested on her side with her vent facing upstream. The eggs were forced out at the moment that the male's body was thrown into a curve. The breeding act was over in less than a second. The female then swam downstream several feet but later returned to spawn with the same or another male. The male hybrid remained at the same place and was able to spawn again immediately. The breeding act was noted a dozen times within 15 minutes, and the details were observed clearly from a distance of about four feet. No female hybrids were observed at this *Nocomis* nest.

Upon the completion of a spawning act several small fallfish, *Leucosomus corporalis*, dashed to the spot and dug vigorously among the pebbles for eggs. Several times male hybrids were also seen standing on their heads as

if attempting to eat eggs. This behavior may, however, be a primitive type of digging activity such as is developed to a greater degree in *cornutus* males. A search revealed many eggs among and under the pebbles of the nest. Eggs of both *Notropis cornutus* and *Nocomis micropogon* were found, indicating that the nest had been utilized for some time. However, it was impossible to isolate the eggs from a single mating under natural conditions and, as yet, I have been unable to hatch *cornutus* eggs and raise the young. With rare exceptions the *cornutus* females were larger than the hybrid males with which they spawned. Males of *cornutus* probably spawn occasionally with a larger female, but I have not seen it happen in many observations over a period of years. After observing these spawning hybrids for nearly an hour, as many as could be captured were preserved and their identification checked.

On a previous occasion a male *cornutus* was seen spawning with a female hybrid. This observation was also made in Catatonk Creek, just below Candor, on May 31, 1939. At 2:30 P. M. a group of about 30 large *cornutus* males were holding positions over a *Nocomis* nest. About a dozen individuals of *rubellus* were present over the lower side and below the nest. At one time five hybrids were seen occupying the same area, mingling with *rubellus*. A female hybrid which had some red coloration on the anterior third of the body came up over a male *cornutus*, dipped down beside him and went through a spawning act in a manner apparently identical to that followed by a female *cornutus*. No repetitions of this spawning act took place during several hours of observation, although *cornutus* spawned freely throughout the afternoon.

DATA FROM HYBRIDS.

An examination of 18 *cornutus* × *rubellus* hybrids specimens collected over a period of five years in a two-mile stretch of stream of Catatonk Creek below Candor gives some interesting results. These specimens (in the Cornell University Museum) were mostly taken from early May through June, and they could easily be sexed by an examination of the gonads. The sexes were equally divided among these 18 specimens, and all but one small male (60 mm. in standard length) appeared to be capable of producing sex elements. Dr. Carl L. Hubbs informs me that he, too, has found a normal sex ratio in *cornutus* × *rubellus* hybrids, and that these hybrids often show gonads which appear to be ripe and normally developed.

These data are interesting in the light of results obtained from a study of aquarium-produced and natural hybrids of sunfishes as reported by Hubbs & Hubbs (1933), who found several combinations of hybrid sunfishes to be predominantly males (81 to 95 per cent.). The evidence also indicated that the resulting hybrids were sterile. Bailey & Lagler (1938, p. 605) also found a predominance of males (80 to 96 per cent.) in a sample of natural hybrid sunfishes. However, a recently studied collection of a hitherto unreported hybrid sunfish, *Lepomis auritus* × *Lepomis cyanellus*, taken by Dr. A. H. Wright in a pond along the South Branch of the Potomac River, one mile above Franklin, Pendleton Co., West Virginia, on August 14, 1931, shows an altered sex ratio in favor of the females. In this collection (examined by both Dr. Carl L. Hubbs and Dr. Reeve M. Bailey) there were 6 male and 18 female hybrids (25 per cent. males). In this same collection there were 17 males and 14 females of *Lepomis auritus* and 14 males and 17 females of *Lepomis cyanellus*. There also appeared to have been some back-crossing, as some of the hybrids strongly approached *Lepomis auritus*.

There is no direct proof that either males or females of the *cornutus* × *rubellus* hybrids are fertile. However, as has already been mentioned, each sex may perform the spawning act in nature with *cornutus*. Possibly the hybrids may spawn with one another, although this act has not as yet been

observed. Male hybrids have been forced to emit milt upon pressure. The fact that some hybrids appear to be closer in characters to one parent species suggests that they may have resulted from a back cross. Hubbs & Brown (1929, p. 36) reported "our large number of specimens (hybrids) from numerous localities completely bridge over the wide gap in characters between the two parent species." These data also suggest that at times the breeding act involving a hybrid and one of the parent species may be successful.

There is considerable variation in the condition and position of the eggs in the ovary of hybrids taken during May and June. In some the eggs are all enlarged and appeared much as they do in either *cornutus* or *rubellus* females which are ready for spawning. In a few ovaries the eggs are very small and it appears that they would ripen much too late, if at all, for the spawning season. In a few hybrids, for example one 73 mm. in standard length taken on October 18, 1938, several unusually large eggs occur at intervals among many small eggs. It seems that these fish may have retained some eggs from the previous spring.

TABLE I.

Length-frequency distribution of mature hybrids, *Notropis c. cornutus* × *Notropis rubellus* and *Notropis rubellus* taken during May and June from Catatunk Creek, below Candor, New York.

Standard Length in mm.	Hybrids: <i>Notropis c. cornutus</i> × <i>Notropis rubellus</i>		<i>Notropis rubellus</i>	
	Female	Male	Female	Male
44	...	...	...	2
46	...	...	...	4
48	...	...	1	5
50	...	...	3	4
52	...	...	4	1
54	...	...	1	2
56	...	...	1	...
58	...	...	2	1
60	...	1*	1	...
62	...	1	6	...
64	...	1	5	...
66	...	...	1	...
68	...	...	...	...
70	...	2	...	...
72	1	...	...	...
74	...	1	...	...
76	1	1	...	...
78	3	1	...	...
80	...	1	...	...
82	1	...	...	...
84	1	...	...	...
86	...	...	...	...
88	1	...	...	...
90	...	...	...	...
92	1	...	...	...
Number	9	9	25	19
Mean	80.89	70.44	58.00	48.95
Standard Deviation	6.24	7.24	5.77	3.57

*Immature.

Some of the female hybrids had tubercles and some red color on the anterior part of the body but the majority had neither tubercles nor color. Females as well as the males of *rubellus* are tuberculate at the spawning time, and both develop red color. A female *rubellus* in nuptial color is illustrated in Greeley (1930, plate 10). However the male *rubellus* is more brightly colored and has more of the body covered with tubercles. In *cornutus* the female is rarely colored and then usually only on the posterior border of the caudal and anal fins, and she rarely, if ever, has breeding tubercles.

The male hybrids taken during May and June had the breeding color and breeding tubercles well developed. The one exception was a small individual, 60 mm. in standard length, which was sexed without question as a male but was apparently immature. In the hybrids the lips were dusky as in *rubellus*, rather than light colored as in *cornutus*.

As in *rubellus*, the females of the hybrids attain a greater length than the males. Table I gives the length-frequency distribution of 18 hybrids from Catatonk Creek below Candor, New York, collected from early May through June over a period of five years. Length measurements of a random sample of 44 specimens of *Notropis rubellus* in spawning condition, collected at the same locality on June 10, 1939, are included. Seventeen additional hybrids were secured during October, 1938 and 1939, but since most of these specimens were difficult to sex with accuracy they are not included here. However all measurements of these October specimens fell within the range as given in Table I. In *cornutus* the males attain a greater length than the females as reported by Raney (1940, p. 5).

One large hybrid specimen placed in an aquarium in October, 1939, proved to be extremely hardy and outlived several hundred specimens of *cornutus* and *rubellus* placed in similar containers under similar conditions. Not only did he outlive all of the specimens of the parent species, but a dozen other species of cyprinids as well, and is thriving and active at the present time (June, 1940).

SUMMARY.

1. Hybrids between *Notropis rubellus* and several sub-species of *Notropis cornutus* are fairly common in some localities, especially below dams and over *Nocomis* nests during the spawning season in late May and early June.

2. The hybrids apparently result from a chance combination of sexual elements as the parent species spawn at the same spot.

3. Hybrids can be recognized in the field by such characters as body shape and coloration. Male hybrids have well developed tubercles and red colors, as do some female hybrids.

4. Several male hybrids, *Notropis c. cornutus* × *Notropis rubellus*, were observed spawning with female *Notropis c. cornutus* over a pebble nest of *Nocomis micropogon*. On another occasion a female hybrid went through the spawning process with a male *Notropis c. cornutus*.

5. The actual breeding behavior of male hybrids is identical with that of *Notropis cornutus* although their behavior over a nest is similar to that of *rubellus*. Eggs were deposited by *cornutus*. Many hybrids have seemingly normal eggs and milt has been obtained from male hybrids upon stripping.

6. The sexes were evenly divided between 18 hybrids collected during the breeding season over a period of five years.

7. Female hybrids attain a significantly greater maximum and mean standard length than males. This is also true of female *rubellus* but in *cornutus* the males are larger.

8. One hybrid kept in an aquarium over winter appeared to be an unusually hardy individual, outliving all specimens of parent species kept in similar containers under similar conditions.

BIBLIOGRAPHY.

BAILEY, REEVE M. & LAGLER, KARL F.

1938. An analysis of hybridization in a population of stunted sunfishes in New York. *Pap. Mich. Acad. Sci., Arts and Letters*, Vol. 23: 577-606, figs. 1-5.

FORBES, STEPHEN ALFRED & RICHARDSON, ROBERT EARL

1909. The fishes of Illinois. *Nat. Hist. Surv. Illinois*, Vol. 3: i-cxxi, 1-357, figs. 1-76, pls. 1-68.

GREELEY, J. R.

1929. Fishes of the Erie-Niagara Watershed. *In: A biological Survey of the Erie-Niagara System. Suppl. 18th Ann. Rept., 1928: 150-179, pls. 1-8.*
1930. Fishes of the Lake Champlain Watershed. *In: A Biological Survey of the Champlain Watershed. Suppl. 19th Ann. Rept. N. Y. Cons. Dept., 1929: 44-104, pls. 1-16.*
1938. Fishes of the area with annotated list. *In: A Biological Survey of the Allegheny and Chemung Watersheds. Suppl. 27th Ann. Rept. N. Y. Cons. Dept., 1937: 48-73, pls. 1-2.*

HANKINSON, THOMAS L.

1932. Observations on the breeding behavior and habitats of fishes in southern Michigan. *Pap. Mich. Acad. Sci., Arts and Letters*, Vol. 15: 411-425, pls. 33-34.

HUBBS, CARL L. & BROWN, DUGALD E. S.

1929. Materials for a distributional study of Ontario fishes. *Trans. Royal Canadian Institute*, Vol. 17 (Part I): 1-56.

HUBBS, CARL L. & COOPER, GERALD P.

1936. Minnows of Michigan. *Bull. Cranbrook Inst. Sci.*, No. 8: 1-95, pls. 1-10.

HUBBS, CARL L. & HUBBS, LAURA C.

1933. The increased growth, predominant maleness, and apparent infertility of hybrid sunfishes. *Pap. Mich. Acad. Sci., Arts and Letters*, Vol. 17: 613-641, figs. 69-71, pls. 64-65.

RANEY, EDWARD C.

1940. The breeding behavior of the common shiner, *Notropis cornutus* (Mitchill). *Zoologica*, Vol. 25 (Part I): 1-14, fig. 1, pls. 1-4.

RANEY, EDWARD C. & LACHNER, ERNEST A.

1939. Observations on the life history of the spotted darter, *Poeciliichthys maculatus* (Kirtland). *Copeia*, (3): 157-165, figs. 1-2.